Space Technology Research Grants

Resource-Aware Navigation for Shadowed and Uncertain Environments

Completed Technology Project (2013 - 2017)

Project Introduction

Discovery of off-Earth ice will transform space exploration. Volatiles that exist primarily in shadowed polar latitudes of planetary bodes could be harvested to produce rocket fuel and life-support resources. In addition, polar regions can have areas with persistent, grazing light, such as Shackelton Crater on the Moon, that could support permanent operations by avoiding both the blazing heat of equatorial regions and the cryogenic temperatures of night. Recent evidence of ice on the poles of the Moon and Mercury has highlighted the importance of sending a robotic mission to explore the highest latitudes of these and similar planetary bodies. Current rover technologies are unequipped for the perception, navigation, and planning challenges caused by the grazing, non-diffuse light; long, time-varying shadows; cryogenic temperatures; communication instabilities; and uncertainty inherent in these regions. Each of these impacts a robot in a different way: where it can go, what it can see, how much battery charge remains, how cold it is, and whether it can communicate with Earth. Past and current rover missions have avoided these problems by operating only in equatorial latitudes. This research proposes to develop methods for perception and path planning in shadowed, uncertain domains that balance competing demands of mission goals, power and thermal constraints, communication requirements, and uncertainty in a priori terrain maps. It will pursue methods of using active illumination in the dark and avoiding direct glare in the direction of the Sun that will enable sensors to create sufficiently detailed models for navigation in the upper-latitudes. This proposal also hypothesizes that efficient re-planning from an initial plan or set of possible plans can empower a rover to navigate to a goal using only on-board computation, achieving the robustness to unexpected communication dropouts necessary for a robotic mission. This perception and resource-aware navigation will enable long-term autonomy with limited operator supervision in previously inaccessible polar environments including the high latitudes of the Moon, Mercury, and asteroids.

Anticipated Benefits

This perception and resource-aware navigation will enable long-term autonomy with limited operator supervision in previously inaccessible polar environments including the high latitudes of the Moon, Mercury, and asteroids.

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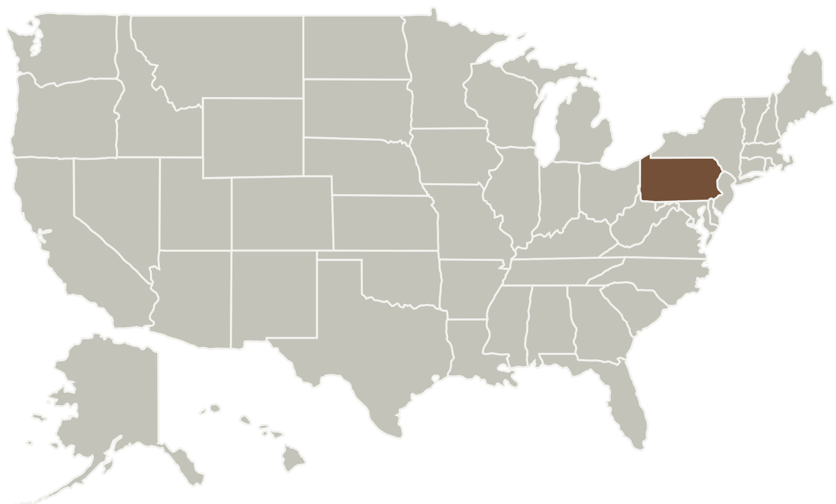
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Carnegie Mellon University	Lead Organization	Academia	Pittsburgh, Pennsylvania

Primary U.S. Work Locations
Pennsylvania

Project Website:

https://www.nasa.gov/directorates/spacetech/home/index.html

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Carnegie Mellon University

Responsible Program:

Space Technology Research Grants

Project Management

Program Director:

Claudia M Meyer

Program Manager:

Hung D Nguyen

Principal Investigator:

William Whittaker

Co-Investigator:

Christopher L Cunningham

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Technology Maturity (TRL)

Start: **2**
Current: **3**
Estimated End: **3**

1 2 3 4 5 6 7 8 9

Applied Research | Development | Demo & Test

Technology Areas

Primary:

- TX10 Autonomous Systems
  └ TX10.1 Situational and Self Awareness
    └ TX10.1.1 Sensing and Perception for Autonomous Systems

Target Destinations

The Moon, Mars, Others Inside the Solar System